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ADVANCED PLANNING AND EARLY WARNING FOR THE WARFIGHTER

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Abstract

Current tactical/operational software and doctrine do not provide the warfighter early warning against intercepted or non-intercepted missiles, especially when containing chemical/biological agents. Nor does the warfighter have the capability to operationally plan for these eventualities. The U.S. Army Chemical School plans to connect the Post Engagement Ground Effects Model (PEGEM) to the Global Command and Control System (GCCS) to provide this capability. Operational doctrine must also be expanded to cover these eventualities. Experience gained through using PEGEM during training exercises provides valuable insight into how best to protect the warfighter while also training Tactical Operation Center (TOC) personnel in the realities of chemical/biological warfare (CBW). The use of PEGEM during training exercises requires headquarter units to think in terms of the larger battlefield picture, not just the immediate missile defense problem. In the future, deployed units will have the capability to assess the effects from missile intercepts or non-intercepts. These effects can alter the progression and outcome of a battle.

Introduction

Historically, operational planning and early warning has concentrated on conventional weapons, not on chemical/biological warfare (CBW). Tactical Operation Center (TOC) personnel plan with the intent to maximize coverage over assets by missile defense batteries. Not included within this planning is consideration of potential ground effects from missile intercepts and payload variations such as chemical/biological weapons. It is not desirable to have surviving munitions or chemical/biological agents affect military assets or civilian population centers. During the battle, timely early warning messages to the warfighter and civilian population centers can reduce casualties and improve unit effectiveness.

A hit is not necessarily a kill in missile defense. In fact, a missile kill does not mean that the missile payload has been destroyed. Missile payload destruction is the goal of missile defense, not missile kill. During the Gulf War, air defense batteries intercepted theater ballistic missiles (TBM) carrying unitary high explosive (HE) payloads. Not all of these intercepts were successful. Some warheads missed the targeted TBM, while others hit the missile but missed the payload section. The results were the same - the surviving TBM detonated upon impact with the ground. These same missiles could have been launched with unitary chemical payloads during the war, but fortunately were not. For the warfighter, it is important to understand and assess potential missile threats whether intercepted or non-intercepted.

The U.S. Army Space and Missile Defense Command (SMDC) developed the Post-Engagement Ground Effects Model (PEGEM) to assess ground effects resulting from the intercept or non-intercept of missiles containing chemical/biological agents, high explosives (HE), and debris. Soon thereafter, the SMDC Battle Lab incorporated PEGEM into its synthetic battlefield environment (SBE) to provide dirty battlefield effects. Integration of PEGEM into the SBE allowed other simulations and tactical systems to utilize a realistic, dirty battlefield environment that includes CBW, collateral HE effects, and debris. PEGEM also provided ground sensor models that transmit nuclear, biological/chemical (NBC) messages based on the NATO ATP-45[1] standard. This initiated the use of PEGEM in training exercises.

The U.S. Army Chemical School has designated PEGEM a critical technology for the warfighter. Discussed below are operational/tactical requirements, tactical early warning, operational planning, training exercise usage, and a concise description of PEGEM.

Operational/Tactical Requirements

For the past few decades, NATO has relied upon ATP-45 to prescribe the procedures to be followed by the land, air, and naval forces for reporting NBC attacks and predicting hazard areas. In 1994, an update to

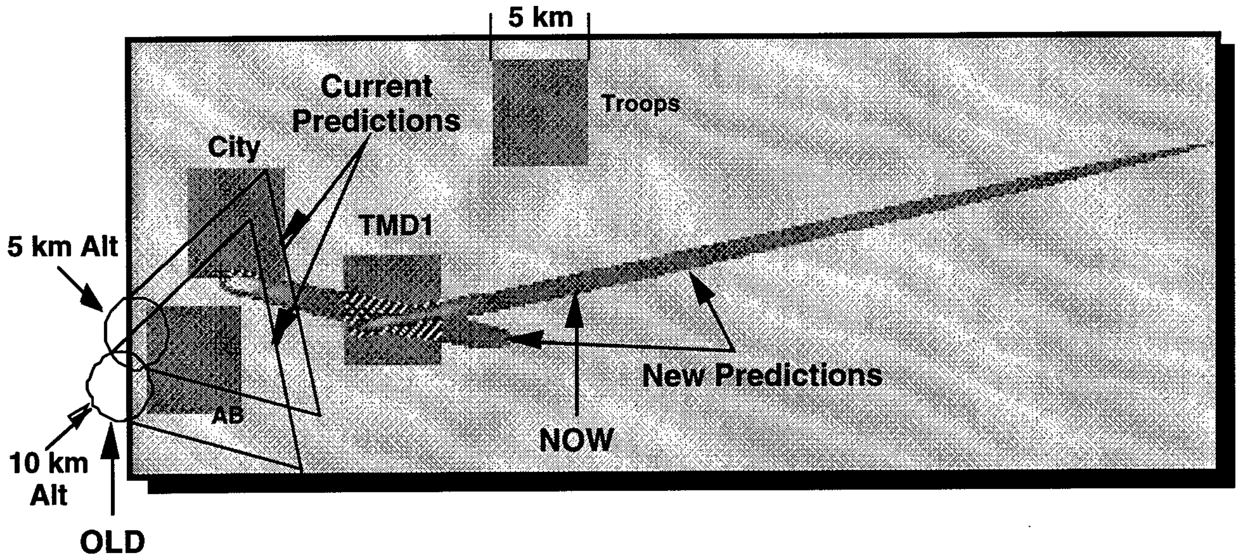


Figure 1
High Altitude Release (> 1km) Early Warning: ATP-45 versus PEGEM

ATP-45 became effective upon its receipt. CBW attacks can be delivered by a wide variety of means: aircraft bombs or missiles, multiple launch rockets, artillery or mortar shells, missiles, cruise missile or aircraft sprayer, or generators. However, all of these attacks are based upon low altitude or ground release of the agent. High altitude CBW agent release whether by offensive deployment or intercept is not provided for in ATP-45. Only with the advent of missiles and missile defense systems has this become important. Additionally, powerful computers and improved computer simulations provide a means for tracking both high and low altitude releases effectively. Figures 1 and 2 illustrate a high and a low altitude release as predicted by ATP-45 and PEGEM.

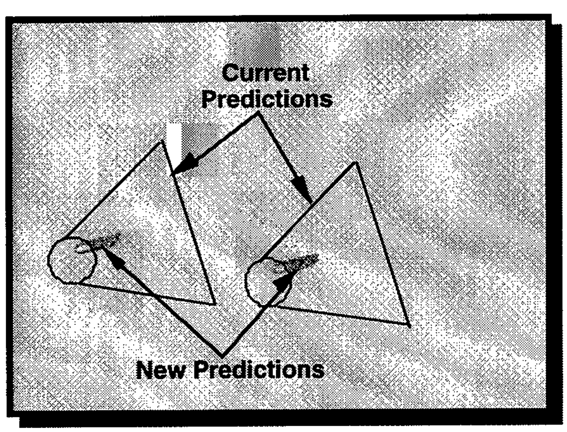


Figure 2
Low Altitude Release (≤ 1 km) Early Warning: ATP-45 versus PEGEM

In the past, because of the inability to calculate CBW agent transport and diffusion, availability of accurate meteorological data, and lack of information about threats and their payloads, large uncertainties were associated with each attack. This required a conservative NBC reporting methodology. Large regions were designated as hazard areas. Attacks were assumed to only be from low altitude or ground level. All units within those zones must respond to the potential attack. This reduced unit effectiveness and possibly identified the wrong hazard area location, size, and contamination levels.

Attack prediction is dependent upon the means of delivery, the type of attack, the meteorological conditions, and terrain. This paper limits its discussion to only missile attacks. Missiles carry a wide variety of warheads, each capable of fulfilling a unique mission. Most countries with missiles have limited inventories with a limited variety of payloads. An understanding of the different missile payload configurations provides insight into the needs of the warfighter for tactical early warning and operational planning.

Means of Delivery

Missiles fall into two categories: ballistic or air breathing (e.g., cruise). Attack range may be thousands of kilometers to tens of kilometers. Altitudes and speeds also vary depending on the threat missile and the trajectory chosen. The one thing all missiles have in common is a payload. The most common missile payload is a unitary high explosive (HE) payload. This is the payload of the Gulf War. The warhead may detonate upon impact with the ground or fuze at a predetermined altitude. If the missile payload is successfully intercepted, the warhead detonates and only small debris falls to earth.

A second type of conventional missile payload contains HE submunitions. The submunitions are ejected at a predetermined altitude and spread out across a region. Detonation usually occurs upon impact with the ground. Unlike the unitary HE payload, a successful intercept does not guarantee destruction of all of the submunitions. This is because of the added protection the submunition wall provides the HE. Surviving submunitions may function normally upon impact with the ground. Large chunks of debris from dead or damaged submunitions can cause impulse damage to equipment, structures, or death to personnel.

Missiles carrying chemical/biological payloads present different problems than conventional HE weapons. A unitary chemical payload missile may release its chemical payload at a predetermined altitude or upon impact with the ground depending on the type of agent used and how the agent is weaponized. Ground hazard may be by inhalation or through contact with droplets. Large areas may be affected for extended periods of time. Intercept of a unitary chemical missile payload only destroys a fraction of the chemical agent. However, if a non-persistent agent (ground burst deployment) was carried in the payload then the threat has been eliminated except for debris. Persistent agents pose a potential ground threat even from high altitude intercepts. The agent disperses into small droplets that may spread over a large area, contaminating the ground with low levels of agent. Debris from an intercepted chemical missile also poses a ground hazard because of chemical contamination along with large debris impulse damage.

Chemical submunition payloads are a very difficult threat to destroy completely. There is no HE to assist in the destruction and the submunition walls protect the agent. Surviving submunitions may release their agent upon impact with the ground. Large debris impulse damage is possible to personnel and equipment.

Biological agents pose a dangerous threat to personnel on the ground. If the agent of biological origin (ABO) is placed within a submunition, it is difficult to destroy. Even a few surviving ABO submunitions may be as dangerous or more dangerous than an non-intercepted ABO submunition missile. This is because of the high toxicity of biological agents. Intercepted ABO submunitions spread out over a larger region than non-intercepted ABO submunitions. Overlapping ABO submunition contamination clouds are unnecessary to maximize casualties.

Nuclear weapons present a unique threat. Large areas may be affected. A series of potential effects must be dealt with. Immediate danger is present from prompt radiation both nuclear particles (neutrons, electrons, and alpha) and electromagnetic radiation (gamma x-ray). The electromagnetic pulse (EMP) can easily damage electrical equipment. Additionally, the thermal flash may cause burns and fires while the blast overpressure damages and destroys buildings and equipment, and harms personnel. Long term health hazards result from the radioactive fallout. Intercept of a nuclear-armed missile may still cause a reduced nuclear detonation that can affect communications and radar, in addition to the ground below. Associated debris contamination must be considered.

<u>Types of Attack</u>

There are two types of chemical/biological attacks: air contaminating and ground contaminating. Air contaminating agents include non-persistent chemical agents and most biological agents. These agents must be inhaled. Non-persistent agents quickly disperse in the atmosphere. Ground contaminating agents are persistent or non-volatile chemical agents. These agents are absorbed through the skin or blister the skin upon contact. Persistent agents, if slightly volatile or very small droplets may form an inhalation hazard also.

The number and variety of chemical and biological agents available throughout the world is large and increasing yearly. Typical chemical agents include nerve, blister, and blood toxins. A variety of means to weaponize these agents is available to countries from simple unitary payloads, thickened or unthickened, to submunitions or sprayers. Biological agents too are very diverse encompassing many common lethal diseases, biological toxins, etc.

Nuclear attacks may be air or ground detonations. Each type has distinct characteristics that are beyond the scope of this paper. But in general nuclear weapons provide short-term effects such as blast overpressure, thermal flash, and prompt radiation, and EMP. Long term effects encompass radioactive fallout.

<u>Meteorology</u>

The influence of weather on the effectiveness of chemical/biological attacks or radioactive fallout has been known for a long time. There are many meteorological factors that must be considered. The rate of evaporation of a liquid chemical agent varies with the temperature. High temperatures increase the evaporation rate. The air stability or differences in air temperature at different levels impact the effectiveness of a chemical attack. The more stable the air the more effective the chemical attack.

Wind speed and direction dramatically affect the spread of chemical/biological agents. High winds also increase the rate of evaporation of liquid chemical agents and the rate at which chemical/biological attacks are dissipated. High winds generally increase the spread of agents, increasing the effectiveness of persistent chemical or biological agents. Non-persistent chemical agents are more effective with lighter winds.

Humidity and precipitation alter the effects of chemical/biological agents in different ways. High humidity, for example, will increase the effectiveness of blister agents, but will not directly affect the effectiveness of nerve agents. Heavy or continuous rains will wash away liquid chemical contamination, and light rain after an attack can cause the recurrence of a contact hazard.

The inversion layer can affect chemical/biological attack effectiveness. Inversion layers rise and fall over the course of a day. The concentration of chemical/biological agents will be higher within the layer than with no inversion. If chemical agents are released above an inversion layer then the reverse may be true that less agent will be within the inversion layer.

Terrain

Also important is the influence of terrain on the effectiveness of chemical agents. The path and speed of a chemical/biological agent cloud is considerably influenced by the nature of the terrain in the downwind area. Under stable conditions chemical/biological clouds tend to flow over rolling terrain and down valleys. Dangerous concentrations may persist in hollows, depressions, and trenches. Chemical/biological clouds tend to go around obstacles such as hills. Rough ground including tall grass and bushes tend to retard chemical clouds. Flat terrain allows for an even, steady movement.

Tactical Early Warning

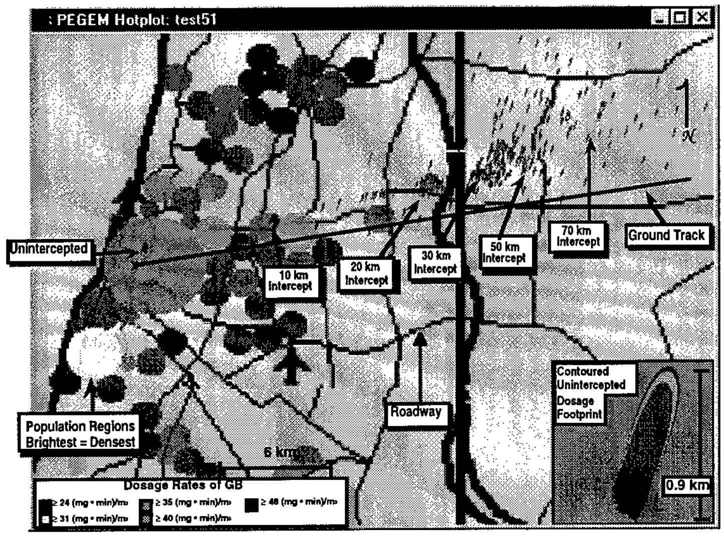
Current doctrine does not provide the warfighter with accurate early warning in many situations. Intercepted missiles are an example where missile defense systems may alter the ground effects. When missile attacks occur, the warfighter is faced with a variety of potential payloads. The more likely payloads being HE or chemical weapons. At the moment of attack, the missile payload is usually unknown. To ignore a potential chemical/biological attack could have an adverse affect on the battle.

Effective early warning requires current up-to-date meteorological data for the area of the attack. Delays in receipt of meteorological data adds uncertainty in accurately predicting the attack. The warfighter should be able to receive multiple weather reports. U.S. military systems are migrating to the Integrated Meteorological System (IMETS) currently being fielded. Wind data – surface and at altitude, humidity, temperature, and pressure should be available. NATO currently relies upon ATP-45, a basic wind message (BWM) and chemical downwind message (CDM). The BWM provides wind data at two-km increments up to 30 km in the atmosphere. The CDR provides wind data at the surface of the ground for two-hour intervals. Missing is current temperature and pressure data. However, above the surface of the earth temperature is fairly constant while pressure variations depend on altitude and high/low pressure systems.

A typical missile attack requires the passive defense cell within the TOC to receive immediate notification of a missile attack. The notification should identify the potential threat missile, the interceptor system, and the engagement parameters – threat position and velocity. Intercept at high altitude does not assure destruction of a unitary chemical payload. If no intercept occurred, the engagement conditions would be the estimated missile impact/deployment location. An intelligence assessment should exist identifying potential threat payloads for the missiles. A series of PEGEM analyses can be performed to assess the potential threat and identify the worst case. In most suspected CBW cases, a predictive NBC message is transmitted to the TOC.

Interceptor system information is necessary to assess body-to-body or fragmenting warhead lethality. The damage and destruction from a body-to-body interceptor is much greater than for a fragmenting warhead. For a unitary chemical payload, the percentage of agent destroyed is determined. For a submunition threat, not only is the number of submunitions destroyed determined but potential ejection velocities for surviving submunitions is calculated.

Intercept altitude affects the ground hazard in two ways. The higher the intercept, the farther from the intended aimpoint the contamination hazard falls, commonly called shortfall. Additionally, higher altitude intercepts result in larger ground hazard areas. For submunitions, the ground pattern is larger resulting in lower concentrations of agent. This is good for chemical threats but not biological submunitions because of the high toxicity of biological agents. Potentially more casualties could result from an intercepted biological submunition threat than if it was allowed to function normally. Intercepted unitary chemical threats create large hazard areas of low concentrations. Figures 3 and 4 illustrate the effect of intercept altitude on a chemical submunition and unitary chemical threats, respectively. Low flying cruise missiles present a very difficult threat because of the low altitude and low speeds. The payload is



- **Meteorological Profile:**
  - **February 1993**

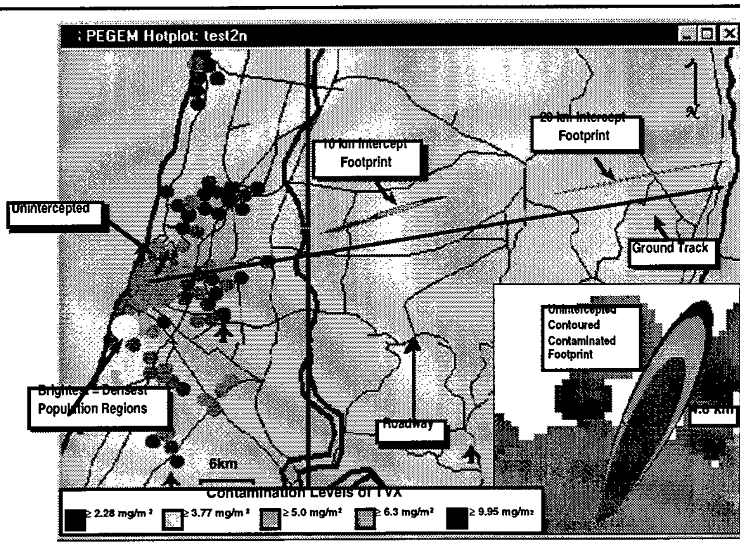
- **Agent: GB**
- **MMD 150µm**
- **50% of Canisters Destroyed from Intercept**
- **60% Agent Dissemination Efficiency at Submunition Function**
- **Shortfall Distance**
  - **10 km Intercept: 7 km**
  - **20 km Intercept: 17 km**
  - **30 km Intercept: 18 km**
  - **50 km Intercept: 22 km**
  - **70 km Intercept: 24 km**
- **GB Casualties Unintercepted: ~ 2000**
- **Total Area of Contoured Unintercepted Dosage Footprint: 0.15 km2**

Figure 3
Effect of Intercept Altitude on a Chemical Submunition Ground Pattern

difficult to destroy and is guaranteed to reach the ground.

Shortfall guarantees protection of a defended asset most of the time, weather permitting. However, personnel or equipment in the vicinity of the shortfall can be adversely affected. This includes both chemical/biological and debris hazards.

Effective NBC early warning messages provide the warfighter time to respond, thereby saving lives and minimizing the troops affected. Multiple or compound NBC early warning messages may be required to identify potential hazard areas due to combinations of chemical/biological agents and the associated contaminated debris resulting from intercept. The NBC



- **Agent: TVX**
- **Meteorological Profile: February 1993**

Unitary Chemical Unintercepted Released at 1,000 m

- **TVX Casualties: 28,000 (Unprotected Population)**
- **MMD 360 µm**
- **Total Area of Contoured Contaminated Footprint: 4.7 km2**

Unitary Chemical Intercepted at 10 km

- **Shortfall Distance: 22 km**
- **20% Agent Destroyed from Impact**
- **MMD 1500 µm**
- **Total Area of Contoured Contaminated Footprint: 10 km^2**

Unitary Chemical Intercepted at 20 km

- **Shortfall Distance: 62 km**
- **20% Agent Destroyed from Impact**
- **MMD 1500 µm**
- **Total Area of Contoured Contaminated Footprint: 7 km2**

Figure 4
Effect of Intercept Altitude on a Unitary Chemical Ground Pattern

message, called a predictive NBC 5 message, replaces the NBC 3 early warning message that over predicts hazard areas, thereby, reducing the units effected.

Operational Planning

Operational planning defines requirements unique from tactical early warning. The main concern of operational planning is to optimize the defense of assets by properly siting units. If CBW attacks occur along known flight corridors, then ground units may be placed to minimize exposure to attack and collateral effects. Similarly, attack planning tries to maximize asset damage. The following discussion concentrates on defensive planning but the concepts may be extended to attack planning.

Several factors must be considered including meteorology, defended asset location, population centers, interceptor capability, and the potential missile payloads. Weather forecasting is very important for planning. Because weather forecasting is an inexact science especially for long range forecasts, large uncertainties are easily introduced into planning results. The need for detailed information concerning future wind, temperature, humidity, and pressure introduces additional uncertainty. It is also possible that weather forecast data may not always be available on the battlefield. This necessitates the use of current weather data. Unfortunately, there is no guarantee that tomorrow or next week the weather will be similar. A statistical approach must be used to account for weather forecast uncertainty.

Defended asset location(s) when added to the weather data limits the defense. Wind direction may not permit placement of ground units where desired without risk of exposure to attack, especially CBW. If a minor adjustment in unit location provides equal defensive capability but improved unit effectiveness under attack it should be performed. Air defense missile batteries must be carefully sited to provide optimal coverage, thereby, limiting ground effects. For example, coastal locations may be difficult to defend when missile attacks occur near those areas because on-shore winds drift chemical/biological clouds back onto defended assets even from missile intercepts.

Population centers may require protection because of political considerations. If population centers are included as defended assets, then almost no surviving chemical/biological agent can reach the ground. A difficult task, for areas with high population densities, or towns and cities near each other.

Interceptor systems place constraints such as intercept range and altitude, along with their inherent capability to effectively destroy an incoming missile payload. Defensive planning requires analyzing all potential scenarios that may occur. Multiple combinations of missile threats and their payloads must be simulated and the potential ground hazards assessed.

A typical defensive planning session may consist of the following task – determine the intercept requirements for keeping ground hazards away from a high priority asset. The military planner identifies attack directions either through an attack angle from true north or by determining potential launch sites and high risk ground assets. Intelligence provides information about possible missile threats (e.g., scud) and their payloads. Meteorological data forecasts are received for the area(s) of interest. The planner determines which missile defense systems are available for use and their estimated placement. Based on the interceptor system capability, intercept altitudes or down range intercept distances are specified. All engagement conditions for the threat (including different payloads)/interceptor combinations are computed and ground effects assessed. Decisions can then be made concerning risks, unit placement, etc. Additional runs may be required to assess new or modified conditions. Figure 5 illustrates locating a missile defense battery near an asset with coverage zone around the battery with an attack direction specified. Ground hazards are also shown.

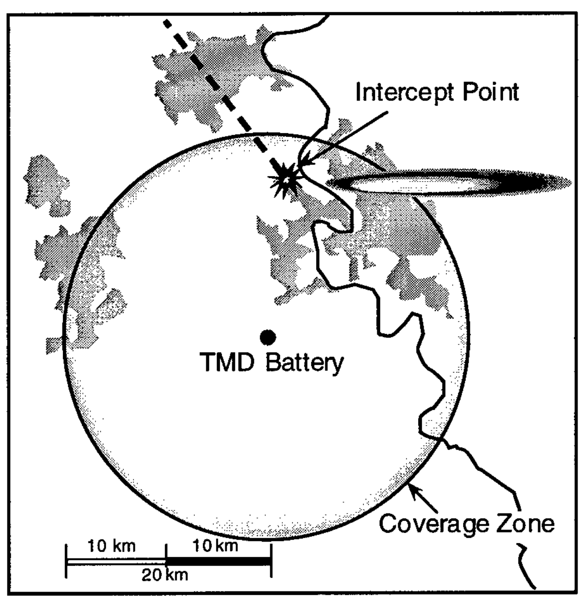


Figure 5
Operational Planning

Operational planning is needed at different command levels, from battalion to the highest levels. Battalion is concerned with unit placement while higher command levels address general battlefield placement and conditions.

Training

Training exercises provide opportunities to not only train the warfighter but also improve doctine. Training exercises such as Home Station Training, Roving Sands, Optic Diamond, Joint Project Optic Windmill (JPOW), and the Joint Training Exercises have begun to incorporate chemical effects in their training exercises. Both operational planning and NBC early warning messages may be involved such as occurred in JPOW-3. NATO members are also very interested in enhanced planning and early warning capability as observed during JPOW-3 of this year.

In order to incorporate enhanced warfighter planning and early warning capabilities into a training exercise, it is necessary to simulate CBW in addition to conventional warfare. However, most simulations currently do not contain CBW capabilities and only limited conventional weapons capabilities. The U.S. Army SMDC Battle Lab incorporated these dirty battlefield effects into their synthetic battlefield environment by making PEGEM distributed simulation compliant. PEGEM monitors the distributed simulation network, when a CBW attack occurs, the associated ground effects are calculated and the results transmitted to the other simulations. NBC sensors may respond to the contamination hazard and send an NBC message to the passive defense cell. A training exercise may require PEGEM participation in both the White Cell (simulation center) to create the dirty battlefield effects and also the TOC to generate predictive NBC messages based communicated information.

PEGEM

A short description of PEGEM and its capabilities to address early warning and operational planning is provided below. PEGEM is a comprehensive simulation tool that provides ground hazard assessment for CBW release and HE weapons. Model output includes chemical/biological agent ground contamination, HE blast/fragmentation zones, data for unit effectiveness or many-on-many models, as well as estimated casualties at user-specified times-of-interest. PEGEM encompasses a number of modeling areas in order to assess ground effects from unitary (bulk) and submunition (canister or bomblet) payload intercepts and non-intercept deployments.

Payload and agent type requires specific algorithms to accurately model ground effects. These algorithms are tailored to each type and are only employed when required in every scenario. In a typical case, the analyst specifies a chemical or biological weapon event scenario including threat information and the locations and times of the various events. Intercept lethality information can be provided through the output of an endgame lethality model. The lethality model provides PEGEM with a prediction of the fraction of payload agent or submunitions surviving following an intercept event. For canister submunition payloads, the location of surviving submunitions within the target payload are given. This information is used by PEGEM to propagate the potential residual threat(s) to the ground.

Given the intercept lethality data from the engagement for submunition payloads, PEGEM determines the ejection velocity vectors of surviving submunitions using a semi-empirical methodology validated by tests. Once initial velocity vectors are determined, submunitions are propagated to the ground using a three degree-of-freedom (3-DOF) model with averaged tumbling munition drag data. Certain munitions with more complex flight characteristics require use of a six degree-of-freedom (6-DOF) model. With either flyout approach, wind effects on submunition propagation are included. MET data are provided to PEGEM through a stratified atmosphere model that provides wind velocity as a function of altitude along with pertinent atmospheric parameters at specified times. A MET profile can be specified at multiple times to help simulate operational battlefield environments, which can be linearly interpolated by PEGEM in flyout calculations.

In contrast to submunition payloads, unitary (bulk) chemical payload analyses requires PEGEM to characterize the initial chemical agent source cloud that results from a unitary threat intercept, or a non-intercept release into the atmosphere. This model determines chemical agent line source length, lateral dimension, removes in situ losses, accounts for aerosolization (losses due to atmospheric interaction), and agent droplet size distribution as a function of release conditions. This empirically based approach is derived from extensive agent simulant testing.

Once the initial agent source cloud is described, an atmospheric transport and diffusion model such as the Vapor, Liquid, and Solid Tracking (VLSTRACK) model[2] or SCIPUFF[3], determines ground deposition, dosage, and concentration from a unitary chemical release. These models calculate the transport, evaporation, and diffusion of tri-variate Gaussian puff clouds of liquid, vapor, and in some cases, solids. Since PEGEM casualty calculations are based on short-term cumulative contamination levels, the atmospheric transport model is normally run in a cumulative mode. As with the previously described flyout models, the atmospheric transport model uses interpolated MET data in performing transport calculations. Atmospheric transport model output is in the form of deposition, dosage, cloud size sigmas at user-specified intervals, and concentrations.

Once ground deposition, dosage, and concentration for all threats in a scenario is determined, the final steps in the simulation are to produce contamination grids and calculate casualties. PEGEM convolves atmospheric transport model contamination grids, discrete population data, and probit methodologies for assessing toxicity effects to produce casualty estimates. This approach for estimating casualties uses a standard probit-based methodology originally proposed by D. J. Finney[4] for probabilistically determining response to a pathogen. This approach requires that response data be available in order to determine a median lethal effective dosage or deposition value for the agent in question, along with the probit-response slope which describes the rate of change of effectiveness as dosage or deposition levels change. This toxicity data is often derived from extensive tests on mammals including, in some cases, humans. Chemical agent toxicity data employed by PEGEM are derived from a recent toxicity standard report[5]. Similar standards are currently being compiled for agents of biological origin.

Chemical/biological submunition payloads also require the use of the atmospheric transport and hazard assessment model. Once the ground impact points of submunitions have been determined using the appropriate flyout model, munitions are assumed to undergo normal (usually ground level) agent release. The initial source cloud release points are provided by PEGEM and an atmospheric transport and diffusion model determines the resulting ground deposition, dosage, and concentration. Cloud size sigmas are not furnished for submunition generated agent clouds because they begin as a point source.

HE payloads are handled in a manner similar to CBWs. Offensively deployed unitary HE payloads detonate on or near the ground while those unitary HE payloads that are successfully intercepted are destroyed. However, HE submunitions may survive an intercept. Surviving HE submunitions are handled similarly to chemical/biological submunitions. A lethality model must provide the location of surviving submunitions within the target payload. This information is used by PEGEM to propagate the potential residual live submunitions to the ground using either a 3-DOF or 6-DOF model. Under investigation is a model to impart momentum to the residual submunitions due to HE initiation of submunitions. HE munitions require the use of blast and fragmentation models to comprehensively model HE detonation at or just above the ground[6]. Blast and fragmentation zones are then determined.

Once the ground blast/fragmentation zones are determined, the final steps in simulating the battlefield environment are to produce blast/fragmentation grids and calculate casualties similar to the chemical and biological agent methodology. Blast/fragmentation grids, discrete population data, and probit methodologies for assessing blast effects are convolved to determine casualty estimates. The approach for estimating casualties is a standard probit-based methodology[7,8] for probabilistically determining response to a pressure wave. This approach requires that response data be available in order to determine a median lethal effective pressure value for the HE agent in question, along with the probit-response slope which describes the rate of change of effectiveness as pressure changes. Casualty estimation from fragmentation is to be based on fragment density and kinetic energy.

Debris model integration into PEGEM relies on debris codes such as the U.S. Army SMDC Kinetic Impact Debris Determination (KIDD)[9] or the U.S. Navy Debris models to define the initial debris clouds. The larger debris clouds are deterministically propagated to the ground. Debris contamination zones are determined along with larger debris impulse damage zones. Ground personnel or equipment in the debris impulse damage zones may be damaged or destroyed. The probability of large debris causing collateral effects is very low. However, if enough TBM intercepts occur during a battle, then the cumulative probability of debris causing personnel casualties or equipment damage becomes significant. Debris contamination zones indicate regions were chemical/biological or nuclear material may cover the debris.

Conclusion

In the past, simulations ignored or did not know how to include CBW, debris, surviving HE submunition, nuclear effects, or NBC sensors in their models. Now it is possible to include the dirty battlefield environment in simulations and assess all missile effects. These effects, when they occur, may dramatically affect the direction of the battle.

An operational/tactical version of PEGEM will provide the warfighter with the means to operationally plan and to provide early warning against a variety of missile attacks. PEGEM operational planning and early warning will be needed from battalion to army headquarters. When PEGEM is used as a planning tool, it will process threat types and payload variations, attack direction, intercept altitude, and interceptor systems with the results presented in an understandable concise, and visual format. Map overlays will provide an easy means to understand ground hazard data. When PEGEM is used for early warning, the worst case threat will be of greatest concern. An early warning NBC message will be transmitted upon request when ground hazards threaten assets, civilian populations, or military units. Visual assessment of the results by passive cell personnel will be part of the process.

A graphical user interface will provide the warfighter with easy access to the capabilities of PEGEM. Output will be simple to understand. Interceptor systems and threat missile inventories will be available from which the warfighter may choose. Payload variations and different agents will also be available. A single software package capable of meeting the needs of the warfighter for missile defense and attacks is being developed.

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